

Report Update

May 16, 2018

After our report “Studying the association between structural factors and tuberculosis in the resettlement colonies in M-East ward, Mumbai” was submitted, we received suggestions and recommendations from planners and architects on our study. We have incorporated some of these recommendations and a revised version of the chapter on “Study of Development Control Regulations (DCRs)” and “Recommendations” is given below.

There is also an error that we have corrected:

- The distance between two buildings as per the general development control regulations is Height of the building/3 for **each** building. Hence the desired distance between two buildings of equal height is $2(H/3)$ or $H/1.5$ and not $H/3$ as mentioned in the previous version of this report.

In addition, we have taken this opportunity to:

- Simplify and refine window to room area ratios and density calculations to ensure uniform and accurate comparisons across the three buildings.
- Provide details regarding applicable DCRs and refine the arguments and recommendations.

A corrigendum clearly noting the basic deviations from the previous report has been attached at the end of this submission for clear comparisons.

Please note that these changes **do not change the arguments made in the previous report**. In fact they further strengthen the need for development control regulations to follow the regulations related to natural light and ventilation in the National Building Code and provide a healthy environment in Slum Rehabilitation Authority buildings.

Study of Development Control Regulations

The Government of Maharashtra passed the Slum Rehabilitation Act 1995 (SRA) to rehabilitate eligible slum dwellers and resettle project affected slum dwellers. The SRA policy was adopted to provide eligible slum dwellers formal housing, free of cost, on or close to the site of their existing slums. For this purpose, the policy offers developers incentive FSI to build market rate housing in exchange for free housing for slum dwellers.

Health and hygiene is an important aspect of quality of life and through redevelopment, the government must have sought to provide housing that lifts slum dwellers from unhygienic environment of slums. However, this study shows that the environment of rehabilitated buildings is detrimental to the health of its residents. Specifically, the study establishes a strong correlation between the built form of SRA buildings and the incidence of Tuberculosis (TB).

As mentioned in the previous sections - households in the three colonies belong to the same socio economic group, yet there is a high burden of TB in Lallubhai Compound and Natwar Parekh Compound. These include cases of multi drug resistant TB (MDR) and extremely drug resistant TB (XDR). A negligible number of TB cases were found in the PMG Colony.

Study of design factors, namely access to daylight (Day light autonomy, Sky view factor), natural ventilation (Air velocity) shows that buildings in Natwar Parekh Compound and Lallubhai Compound severely lack natural light and ventilation especially on the lower floors. Comparatively light and ventilation conditions are better in the PMG Colony.

Following the adoption of the SRA policy, a separate set of regulations was added to the Development Control Regulations (DCR) of Greater Mumbai in 1997 to enable Slum Rehabilitation. One of the major deviations from the DCR 1991 in this set of regulations pertained to minimizing the distance between buildings. The built form of Lallubhai Compound and Natwar Parekh Compound is designed using these special regulations under DCR 33(10) that apply to R&R and slum rehabilitation buildings as well.

Comparatively, PMG Colony has generous open spaces between and around buildings as it is perhaps designed using previous building regulations. It also has negligible number of TB cases. The adverse outcomes for Lallubhai Compound and Natwar Parekh compound could be attributed to the provisions in the special SRA DCRs related to natural light and ventilation of buildings.

This section shall examine regulations regarding 'setbacks', 'distance between buildings', design of openings and density and see how it has affected the built form and in turn the environment in the three rehabilitation colonies.

The summary Table 1 given below provides a comparison of special DCRs pertaining to Rehabilitation & Slum Redevelopment buildings with the norms for general residential development and National Building Codes (NBC). The comparison with NBC norms shows a relaxation of norms related to unit density, marginal open space and distance between buildings for rehabilitation and resettlement (R & R) and slum redevelopment buildings. Table 2 shows how regulations are reflected in the design of the three buildings.

Table 1: DCR Comparisons:

DCR Categories	Resettlement & Rehabilitation of PAP 33(13) DCR 1991 & Subsequent Amendments	Slum Redevelopment 33(10) DCR 1991 & Subsequent Amendments	General Residential Development DCR 1991 & Subsequent Amendments	National Building Codes 2016
Permissible FSI	2.5 FSI for plots that are not being redeveloped DCR 33(10) applies for the plots where rehabilitation is happening using redevelopment	Proportion of Rehab: Incentive FSI Island city- 1 : 0.75 Suburbs- 1 : 1 Difficult Areas- 1 : 1.33	Island city = Total 1.8 (1.33 Base FSI x 0.35 Premium) + 1.33 Base FSI Suburbs = Total 2.7 (1 Base FSI + 1 max TDR) + (1 Base FSI + 1 max TDR) 0.35 Premium FSI = 2. 7	Prescribes an FAR of 2 Consumption of FAR subject to other restrictions on height and setbacks
Insitu FSI Consumption & TDR	For plots not under redevelopment: 2.5 FSI rehabilitation in situ 2.5 TDR as compensation to developer of Rehab DCR 33(10) applies for the plots where rehabilitation is happening using redevelopment	Insitu FSI may exceed 3 if existing dwelling units (DU) on site between 500 DU/ha - 650 DU/ha Insitu may exceed 4 if existing DU/ha more than 650 Du/ha Rest floated as TDR	Insitu consumption for general plots: Island city = May exceed 1.8 Suburbs = May exceed 2.7 TDR floating permitted for some conditions	-
Density DU/ Min	500 DU/Net Ha	500 DU/Net ha for regular slum redevelopment 650 DU/net ha for Dharavi Redevelopment Plan	For plots 1 ha and above: Island City 267 Du/Net Ha/FSI Suburbs 200Du/Net Ha/FSI	-

DCR Categories	Resettlement & Rehabilitation of PAP 33(13) DCR 1991 & Subsequent Amendments	Slum Redevelopment 33(10) DCR 1991 & Subsequent Amendments	General Residential Development DCR 1991 & Subsequent Amendments	National Building Codes 2016
Density DU/Max	No limit mentioned		600 DU/Net ha per FSI Island City (1.33) 450 Du/Net ha per FSI Suburbs (1)	For low income housing - 15sqm in size in 4 storied walkups, without possibility of incremental growth- 500 DU/ha is maximum density prescribed Otherwise 125 - 150 DU/gross ha for metropolitan housing
Height	No limit (But until now the buildings have not been taller than 24m i.e. G+7. However there are plans to increase building heights for future)		The height of a building shall not exceed one and half times the total of the width of the street on which it abuts and the required front open space. Unless high rise permitted by Commissioner in accordance with min street widths mentioned in DCR (min street width 9m for building 32 m in height.. onwards)	15 m for low income housing i.e G+4
Setbacks and Step backs	Front and side setback: 1.5m for building up to 24m height 6m for buildings above 24m. 3m where plot abuts DP road 18.3m wide No separate regulations for Stepbacks		Front: Varies from 7.5 to 3 m depending on street width Side and Rear: Width between internal buildings not less than a third of the height of that building above the ground level, rounded to the nearest decimeter subject to a maximum of 20 m. Minimum being 3.6 m. Different for detached buildings and row houses Step Backs allowed on upper floors for taller buildings This norm is separate and distinct for each building/wing	Front - 1.5 m to 6 m depending on street width Side Open Space: For buildings above 10 m in height = Height/3 till the height of 30 m then +1 m for every 5 m height increase subject to a maximum of 20 m. Rear open space: Average width of 3.0 m and at no place measuring less than 1.8 m Step backs allowed on the upper floors for taller buildings This norm is separate and distinct for each building/ wing
Area between buildings	3m min		Width between internal buildings not less than a third of the height of that building above the ground level for each building, rounded to the nearest decimeter subject to a maximum of 20 m. This norm is separate and distinct for each building and wing	H/3 till the height of 30 m then +1 m for every 5 m subject to a maximum of 20 m. Sizes also provided for ventilation shafts for kitchens and toilets This norm is separate and distinct for each building and wing

DCR Categories	Resettlement & Rehabilitation of PAP 33(13) DCR 1991 & Subsequent Amendments	Slum Redevelopment 33(10) DCR 1991 & Subsequent Amendments	General Residential Development DCR 1991 & Subsequent Amendments	National Building Codes 2016
Rehab Unit Size/ Unit Size	Used to be 20.9sqm changed to 25sqm in 2008 A multi purpose room shall be allowed with size upto 12.5 sqm with a minimum width of 2.4 m Each house abuts common passages 2 m min Kitchen can be an alcove no size restrictions Bathroom no size restrictions	No limit to unit size Min habitable room size 9.5 sqm - min width 2.4 m		Min habitable room size 9.5 sqm - min width 2.4 m Multipurpose single room should be at least 12.5 sqm with minimum width of 2.5 m
Windows size and design	One or more apertures, excluding doors, with area not less than one-sixth of the floor area of the room, with no part of any habitable room being more than 7.5 m. away from the source of light and ventilation Habitable Room: At least a window not less than 1 sqm in area, opening directly on to an interior or exterior open space, but not into a shaft Kitchen Window: No Window / direct ventilation requirement - mechanical light an ventilation is fine Bathroom Window: No Window / direct ventilation requirement - mechanical light an ventilation is fine	One or more apertures, excluding doors, with area not less than one-sixth of the floor area of the room, with no part of any habitable room being more than 7.5 m. away from the source of light and ventilation At least a window not less than 1 sqm in area, opening directly on to an interior or exterior open space, but not into a shaft For towers external windows on a floor shall be not less than 2 1/2 per cent of the floor area Bathroom openings (windows, ventilators, louvers) not less than 0.3 sqm in area or 0.3 m in width.		1/6th of the area of room should be window area for warm and humid - 25% higher window area for kitchen If a window is partly fixed, only the openable area shall be counted. No portion of a room shall be assumed to be lighted, if it is 7.5 m away from building
Open Space Requirement	8% min on ground level	For plots over 1001 sqm depending on area of Plot 15% -25% of open space shall be reserved		Layout/plot measuring 0.3 ha or more for recreational purposes which shall as far as possible 15 percent of the area of the layout, or b) 0.3 to 0.4 ha/1 000 persons; for low income housing

Table 2: Comparison of three colonies under current study

	PMG Colony	Lallubhai Compound	Natwar Parekh
Year of approval as per building approval drawings	1997	2003 and 2007	2008
FSI for entire plot area	2.5	2.5	2.5 consumed 2.44
Net Study Area* (After removing Roads on municipal sheets and built up amenity area)	1.75	5.75	5.05**
Number of Units in Study Area (including shops)	1600	6318	5568
Density DU/ net ha in Net Study Area	914	1099	1103**
Area of window for multipurpose room	12%-20% of room area (6% to 10% after accounting for shut pane of sliding window)	10% of room area (5% after accounting for shut pane of sliding window)	16% of room area (8% after accounting for shut pane of sliding window)
Window Design Features	Cross ventilated.	Not Cross ventilated.	Not Cross ventilated and opens to a common passage
Height	G+7 = 24 m	G+5 = 18 m	G+7 = 24 m
Distance between buildings	Mediated through courts measuring 10x10 to 16x16 m. Each building has 4 light wells measuring 5x5m	3 m min distance	3 m min distance
Open Space Requirement	15%	15%	15%
Room Size	21 sqm	21 sqm	21sqm
<p>*NOTE 1:</p> <ul style="list-style-type: none"> *The Net Study Area is different from total plot area mentioned in the municipal drawings. Study areas are the areas of the Colony where the TB study was mostly concentrated. Google Maps was used to approximate the study areas for the three colonies Number of units were derived from the Municipal Drawings – They include vacant units and shops. <p>** NOTE 2: The study area of Natwar Parekh compound is smaller in the Municipal Drawings than shown in the Google map. If that areas is used net density of Natwar Parekh Compound goes up significantly</p>			

A detailed section discussing the DCRs and design of buildings is presented below.



PMG Colony


Net Study Area = 1.75
 Total Number of Units = 1600
 Density/ Net ha = 914 du/ net ha



Lallubhai Compound

Net Study Area = 5.75 ha
 Total Number of Units = 6318
 Density/ Net ha = 1099 du/ net ha



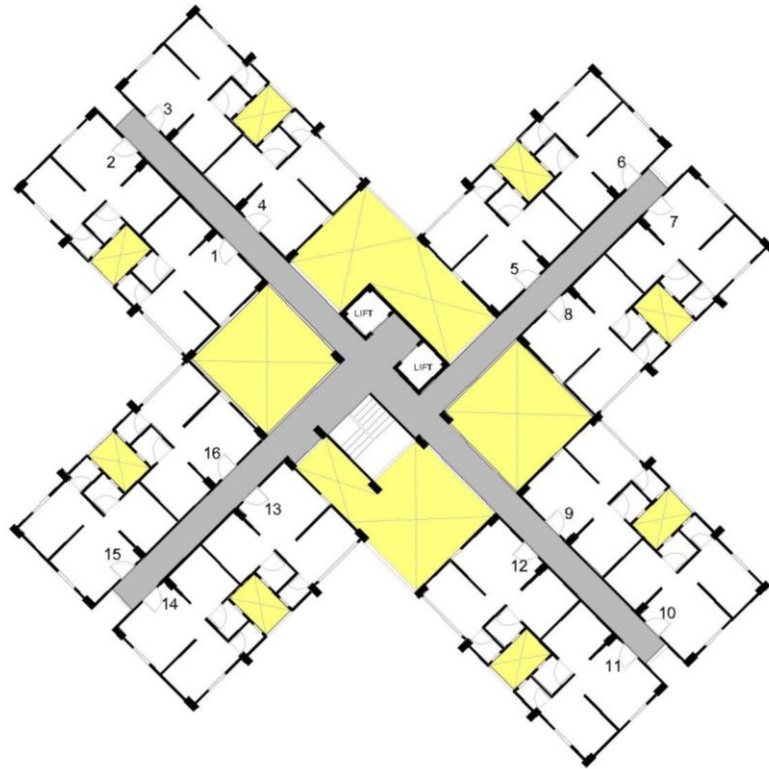
 Net Study Area

Natwar Parekh Compound

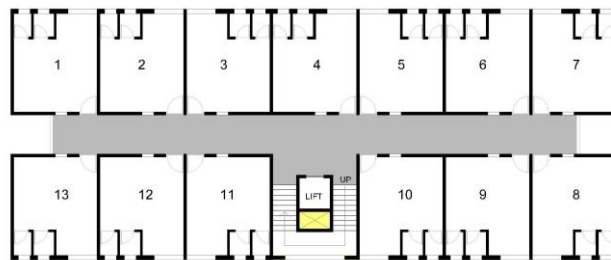
Net Study Area = 5.05 ha
 Total Number of Units = 5568
 Density/ Net ha = 1103 du/net ha

The number of units include shops and vacant buildings

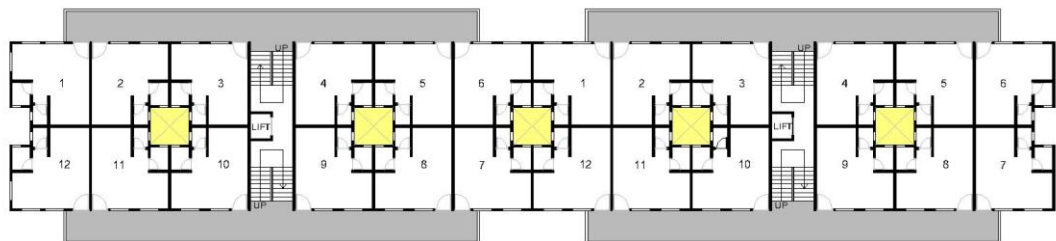
Net study area excludes roads and built up amenities but includes adjoining recreational open space



PMG Colony Building Layout Plan



Lallubhai Compound Building Layout Plan



Natwar Parekh Compound Building Layout Plan

Discussion:

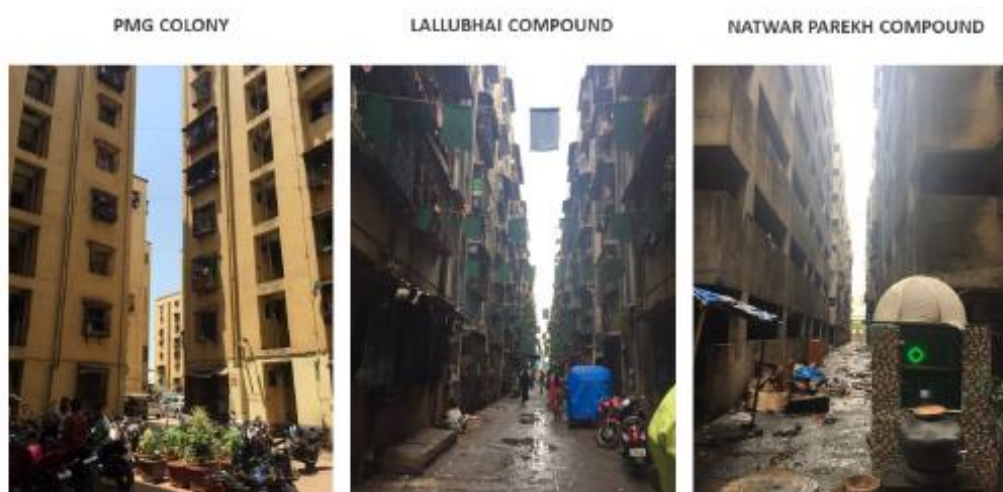
Floor Space Index:

As per the municipal drawings submitted to the building plan department, all three colonies have a permissible FSI of 2.5.

In order to accommodate a higher number of formal dwelling units on the site, the insitu consumption of FSI on a plot has been increased since 1991 to 2015 years from 2.5 to 4. In order to consume this FSI, buildings on the plot are going taller, but the marginal open space and distance between the buildings is fixed at 1.5m and 3m respectively.

Marginal open space and distance in-between buildings:

Close stacking of the buildings in Natwar Parekh Compound and Lallubhai Compound has led to poor light and ventilation, especially on the lower floors in these buildings. The special DCRs for SRA permit this close stacking.



Buildings higher than 10m in height and less than 40 m in length, having habitable rooms that derive light and ventilation on the side and rear faces, the provisions for side and rear setbacks have the following provisions:

- **As per National Building Code (NBC):** Part 3 Development Control Rules and General Building Requirements. DCR 8.2.3 and DCR 8.2.6 for Exterior Open Space and Joint Open Air Space respectively, (page 35 & 36) norms are as follows:

“The open spaces shall be separate or distinct for each building and where a building has two or more wings, each wing shall have separate or distinct open spaces for the purposes of lighting and ventilation of the wings...”

Buildings of height above 10 m, the open spaces (side and rear) shall be as given in Table 4– It states: for building height (H) up to 30 m, side and rear open space to be left around buildings is $H/3$. After 30 m height, for every 5 m increase in building height, 1 m shall be added to rear and side open space up to distance of 20 m.

For joint air space (area in-between buildings) the NBC code says;

“If such interior or exterior open air space is intended to be used for the benefit of more than one building belonging to the same owner, the width of such open air space shall be the one specified for the tallest building as specified in 8.2.3 abutting on such open airspace...”

- **As per General DCRs of Greater Mumbai 1991:** DCR 28(b) for application of setbacks and open space and DCR 29 for Open Space Requirement, Compilation of Development Control Regulations up to 1st January 2015 for Mumbai, (Page 73):

“Side and rear open space in relation to the height of the building for light and ventilation-(1) Residential and Commercial Zones; (a) Building having length, depth up to 40 m.- The open spaces on all sides except the front side of a building shall be of a width not less than a third of the height of that building above the ground level, rounded to the nearest decimeter subject to a maximum of 20 m., the minimum being 3.6 m. for a residential building and 4.5 m. for a commercial building...”

The same, calculated for each building, applies for distance between two buildings

- **As against these the special provision in DCR 33 (10) :**Appendix 4, Section 6.11 and 6.14 - Relaxation in building and other requirements, Compilation of Development Control Regulations up to 1st January 2015 for Mumbai, (page 316) is as follows:

“For building having height up to 24 m in the rehab component or composite building, the front and marginal open space shall be 1.5 m for these buildings. Provided however, that in case of buildings having height more than 24 m the minimum marginal open space shall be 6.0 m or as may be prescribed by CFO...

The distance between any two rehab/composite buildings shall not be less than 3 m.”

Building comparisons with respect to marginal open space and distance in between buildings (joint air space):

In essence the desirable setback is $H/3$ for individual building or $2(H/3)$ i.e. $H/1.5$ as the distance between two buildings of equal height. As against this the SRA rule implies setback of a mere 1.5 m (which translates to $H/16$ for 24 m tall buildings) or distance between two buildings of 3 m (which translates to $H/8$ for 24 m tall buildings). Hence, the distance between buildings in Lallubhai Compound and Natwar Parekh compound is as small as 3m. PMG Colony on the other hand is spaced with courts measuring between 10x10 m up to 16mx16m and has better conditions of light and ventilation.

Window size and design:

Light and ventilation conditions also depend upon the window size and design

- **As per NBC codes - Part 3 Development Control Rules and General Building Requirements.** DCR 20.1.2 on lighting and ventilation (page 57 & 58):

“Rooms shall have, for the admission of light and air, one or more openings, such as windows and ventilators, opening directly to the external air or into an open Verandah ..., the minimum aggregate area (see Notes 1 to 3) of such openings, excluding doors inclusive of frames, shall be not less than... one-sixth (17%) of the floor area for warm-humid climate...;

Note:

1. If a window is partly fixed, the openable area shall be counted.
2. No portion of a room shall be assumed to be lighted, if it is more than 7.5 m away from the opening assumed for lighting that portion.”

- **According to General DCRs of Greater Mumbai 1991:** DCR 42 for Light and Ventilation, Compilation Of Development Control Regulations up to 1st January 2015 for Mumbai, (page 176):

“All parts of any room shall be adequately lighted and ventilated. For this purpose every room shall have -One or more apertures, excluding doors, with area not less than one-sixth of the floor area of the room, with no part of any habitable room being more than 7.5 m. away from the source of light and ventilation...”

And

“An opening with a minimum area of 1 sq. m. in any habitable room including a kitchen, and 0.3 sq. m. with one dimension of 0.3 m. for any bathroom, water closet or store;”

- **SRA rules** do not have separate regulations pertaining to windows for multipurpose rooms. However, Appendix 4, Section 6.3 - Relaxation in building and other requirements, Compilation Of Development Control Regulations up to 1st January 2015 for Mumbai, (page 315) states that:

“for bathroom, water closet or kitchen, there shall be no stipulation of one wall abutting open space, etc. as long as artificial light and ventilation through any means are provided”.

Building Comparisons with respect to Window Size and Design:

Windows in Lallubhai compound are smaller than the prescribed percentage of 17%. Windows for the multipurpose room for Lallubhai Compound are up to 10% of room area¹. Natwar Parekh Compound fares better in this aspect - here the windows are up to 16% but opens to a passage. As a result some residents keep curtains drawn for privacy blocking ventilation. PMG Colony has some homes that have up to 20% window area and another type that has 13%.

However the windows have ½ sliding shutters, as a result of which half the opening remains shut at all times blocking ventilation. If the windows had 1/3 sliding shutters or open able windows they would have bigger openings. Rooms in PMG Colony are also cross-ventilated through two windows on adjacent walls. Natwar Parekh Compound and Lallubhai Compound are not cross-ventilated.

In addition, because homes are small, some households use windows for storage thus further blocking ventilation. Also, bad maintenance has led to filthy common areas in some parts of these colonies. As a result many people on ground floor and first floor chose to keep their windows closed completely shutting off the ventilation.

Density:

As stated in the report above, in the resettlement colonies, larger families had more chances of having a TB patient in the family. In other words, more the number of people sharing a space, higher the probability of TB. The SRA norms promote higher density development. A review of these norms is as given below.

- **For density, the provisions for density in the NBC are as follows:**

As per Part 3 Development Control Rules and General Building Requirements. DCR
In the case of group housing² DCR 9.6.2 (page 41 and 42)

“No limit to floors and height shall be applicable, but the coverage and floor area ratio for various densities may be as given in Table 6 unless provided otherwise in the Master Plan and local development control rules”

Table 6 prescribes a density of 100 Dwelling Unit (DU)/net ha for FSI of 1 which proportionately rises up to 400Du/net ha for an FAR of 4.

In case of low income housing the Annex C (page 137) of NBC further states that:

“In case of developments with per dwelling unit covered area of 15 m², four storeyed walk ups without future incremental growth with maximum densities of 500 dwelling units per hectare shall be permissible. In case of four storeyed walk ups, having two roomed dwelling unit where one room is for future expansion, maximum density of 400 dwelling units per hectare shall be permissible”.

In other words the norms suggest a maximum DU/ha density of 500 but allow master plans to tweak the density norms as per its city's requirements.

Provisions pertaining **densities in the General DCRs** Section 32, Table 14 on Floor Space Indices and Tenement Density, Compilation Of Development Control Regulations up to 1st January 2015 for Mumbai, (page 87) is as follows:

	FSI	Maximum	Minimum (applicable only to plots of 1 ha and above and subdivided plots each of 1 ha and above from larger layouts or sub-division)
(A) Island City	1.33	600	267
(B) (iii) Suburbs	1	450	200

¹ Note in the calculation for windows the small window provided into the common doubly loaded corridor is not counted as it doesn't open up to the external wall.

² 2.43 Housing for more than one dwelling unit, where land is owned jointly (as in the case of cooperative societies or the public agencies, such as local authorities or housing boards, etc) and the construction is undertaken by one Agency.

Further, the DCRs prescribe that the tenement density should be relatively increased as per the increase in FSI. The densities can go even higher in the case in sites allocated for Public Housing/High Density Housing (PH/HDH). As per DCR 32 note on (page 93):

“number of maximum tenement density is prescribed, but the minimum density will be 325 per net hectare for FSI of 1.00. However, in zones in which the FSI is less or more than 1.00 the minimum density of PH/HDH sites will be reduced or increased in proportion to the FSI permissible”

- **As per the provisions in the special DCRs for SRA:**

Appendix 4 Section 3.12 Minimum Density On The Plot Including Non-Residential Units and Section 3.13, Compilation Of Development Control Regulations up to 1st January 2015 for Mumbai, (Page 312):

“The minimum density of rehabilitation component on plot shall be 500 tenements per net hectare, that is, after deducting all reservations actually implemented on site including the land appurtenant thereto, but not deducting the recreational/amenity open space on the remaining area. If the number of tenements to be provided to the hutment dwellers is less than the minimum, the balance shall be handed over free of cost to the Slum Rehabilitation Authority. The Authority shall use them for the purpose of transit or Project-affected persons or pavement-dwellers or slum dwellers from other slums”.... Further it states .. “All non-residential built-up areas shall be included in the computation of minimum density but on the scale of 20.90 sq. m. of carpet area being one tenement”

Building Comparisons with respect to density:

Average number of people per household in resettlement colonies is 5.3 as compared to 4.6 in the rest of the city. This increases the people density in these neighbourhoods as compared to the rest of the city.

The number of units per hectare is larger in Natwar Parekh and Lallubhai Compound as compared to PMG Colony. The number of units/net ha in Natwar Parekh is approximately 1103 units/net ha while in Lallubhai Compound it is approximately 1099 units/net ha. In PMG Colony density is approximately 914 units/net ha. These densities are not drastically different from each other. However, the difference in built form and bad maintenance creates an environment that breeds TB pathogen in Lallubhai compound and Natwar Parekh compound.

Thus we see that dark and damp surroundings due to poor design and maintenance make these colonies a breeding ground for the TB pathogen. High people density and poor ventilation brings a large number of people in contact with the pathogen increasing the risk of contagion.

Discretionary powers:

Its important to note that although, as per Section 63 on Discretionary powers (Compilation Of Development Control Regulations up to 1st January 2015 for Mumbai, page 236), it is stated that:

“in specific cases where a clearly demonstrable hardship is caused, the Commissioner may for reasons to be recorded in writing, by special permission permit any of the dimensions prescribed by these Regulations to be modified”

The section only allows relaxations

“...provided that the relaxation will not affect the health, safety, fire safety, structural safety and public safety of the inhabitants of the building and the neighborhood”.

It could thus be seen that health and safety of occupants is of paramount importance. Therefore while devising separate set of regulations as well, health and safety of residents should not be compromised. So far, the rule has been used to provide concessions to the marginal and joint open space for all buildings. This should be stopped. In the light of the TB study findings, relaxations to the norms related to light and ventilations amount to a violation of the provisions in Section 63, as these relaxations are detrimental to the health of the inhabitants.

Recommendations

In the light of this study two sets of recommendations are suggested:

A. Changes to DCRs :

The findings suggest that relaxation in building standards for slum rehabilitation and redevelopment are detrimental to the health of the poor who inhabit these homes and must be amended. Hence -

1. Exceptions made in DCR 33(10) – Appendix 4, Section 6.11 and 6.14 on marginal open space and area between two buildings should be removed and general DCRs should be followed for the same.
2. Adoption of these regulations may not make it possible to attain the minimum requirement for densities. Hence it is recommended that regulations pertaining to minimum density in SRA buildings should also be removed.
3. For windows, we recommend that General DCR 42 be changed to read as:
“All parts of any room shall be adequately lighted and ventilated. For this purpose every room shall have - One or more apertures, excluding doors, **with openable area** not less than one-sixth of the floor area of the room, with no part of any habitable room being more than 7.5 m. away from the source of light and ventilation.”
This DCR should be applied to DCR 33(10) without exceptions.
4. Do not allow authorities to provide concessions that compromise the light ventilation of homes, especially in low income and slum rehabilitation colonies as residents cannot afford the costs of artificial light and ventilation.

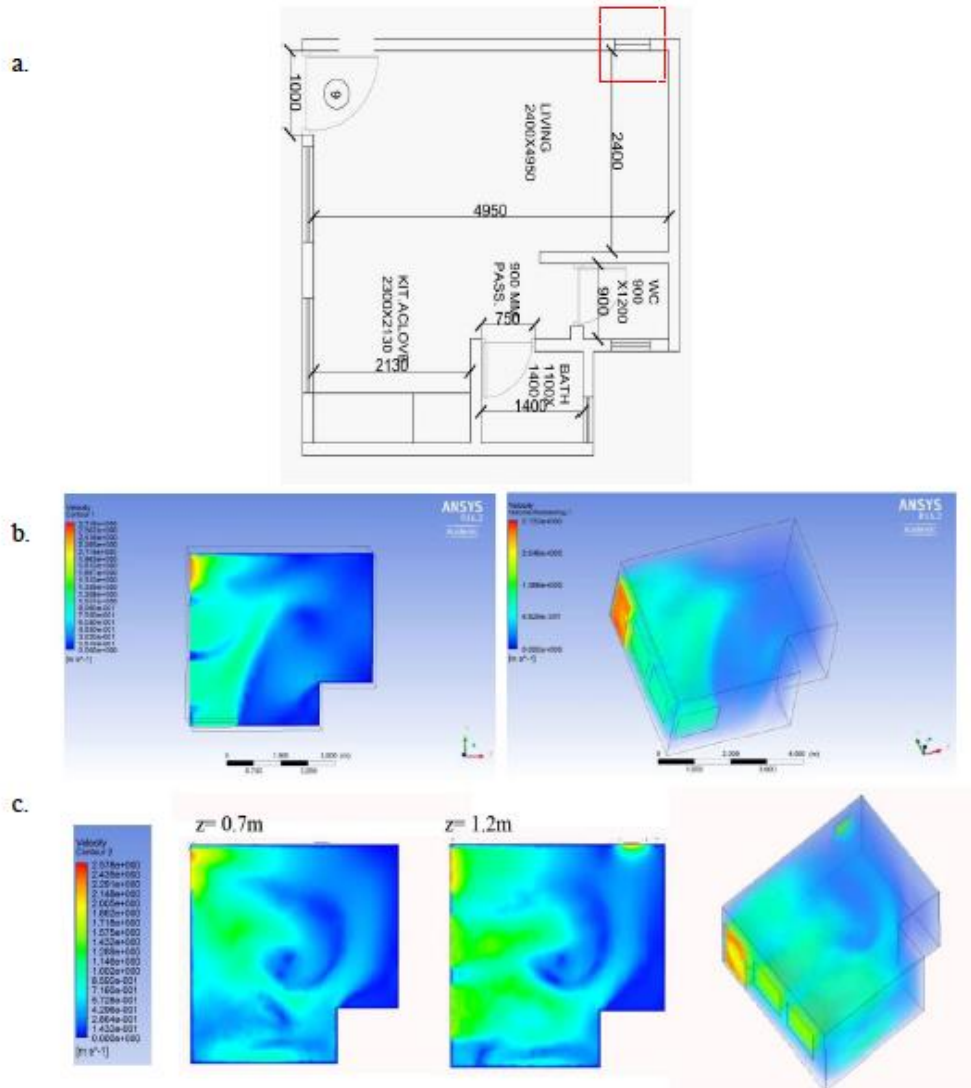
B. Retrofitting of Existing Buildings:

To improve the light and ventilation conditions in SRA buildings already constructed under existing regulations, it is recommended that the following retrofitting measures be undertaken:

- All existing SRA buildings that have problems of ventilation should be retrofitted with appropriately placed exhaust fans.
- Three-leaf sliding windows or fully openable windows should replace the existing two-leaf sliding windows for better ventilation
- Ventilators on the wall/door: One of the scenarios – _an extra window in the living area of a tenement of Natwar Parekh compound- was modelled and simulation experiments were performed in order to see the possible impact of the intervention on the natural ventilation in the house (see fig below). It was observed that by addition of this extra window, the air velocity in the living area increased considerably because of the cross ventilation. Since, none of the houses in this Colony have any windows for cross ventilation, this intervention may help in maintaining a healthier atmosphere in the house.

C. Study of Layout Design:

Well designed layouts can make a difference to final conditions of light and ventilation. Further modeling studies, similar to the ones carried out in this report, could be conducted to see the effect of light and ventilation in the rooms using the step back methods of building and different building and open space layouts.



Simulation studies for a model with an extra window introduced in a house in Natwar Parekh compound. a. The design of the simulated house. Red box shows where the window was introduced, b. Velocity contour and volume rendering of the house before introducing the extra window, c. Contour and Volume rendering of the air velocity in the modelled house with the new window.

Corrigendum

The following section records the deviations between this report (submitted in May 2018) and the earlier version of this report submitted to MMRDA in April 2018

Study of Development Control Regulations

This section of the report takes detailed look at the DCRs governing the built form of resettlement and rehabilitation colonies like PMG Colony, Lallubhai Compound and Natwar Parekh Compound.

Table 14 given below compares the DCRs for Rehabilitation & Slum Redevelopment buildings with the norms for general residential development and National Building Codes. The comparison shows a relaxation of norms related to unit density, open space, distance between buildings for slum rehabilitation buildings and a lack of regulations on window design for light and ventilation. Further comparison of rehabilitation and redevelopment DCRs since 1991 shows that over the years, norms have been modified to increase the size of individual units and FAR but decrease the distance between buildings to allow for a higher density of units and higher FAR built up area. But this is not all, in order to accommodate a larger group of people further concessions in setbacks and distances may be granted for a rehabilitation or slum redevelopment project. These concessions can exacerbate the already poor quality of light and ventilation in these projects.

These DCR changes are reflected in the three buildings that we have studied. PMG Colony is the oldest among the three. Its blue prints municipal drawings were approved in December 1997. Lallubhai Compound was built next. A part of Lallubhai compound was approved on August 2003 and another part in 2005. Natwar Parekh Compound's plans were sanctioned by the SRA cell in MMRDA in March 2008. Table 15 provides details on the built form of these buildings.

Table 24: DCR Comparisons

DCR Categories	Resettlement & Rehabilitation of PAP 33(13) 1991 & Subsequent Amendments	Slum Redevelopment 33(10) 1991 & Subsequent Amendments	General Residential Development 1991 & Subsequent Amendments	National Building Codes 2016	Proposed DCRs for Slum Redevelopment 33(10) – Released in 2016	Proposed DCRs for General Residential Development Released in 2016
Permissible FSI	2.5 FSI for plots that are not being redeveloped DCR 33(10) applies for the plots where rehabilitation is happening using redevelopment	Proportion of Rehab: Incentive FSI Island city- 1 : 0.75 Suburbs- 1 : 1 Difficult Areas- 1 : 1.33	Island city = Total 1.8 (1.33 Base FSI x 0.35 Premium) + 1.33 Base FSI Suburbs = Total 2.7 (1 Base FSI + 1 max TDR) + (1 Base FSI + 1 max TDR) 0.35 Premium FSI = 2.7	Prescribes an FAR of 2 Consumption of FAR subject to other restrictions on height and setbacks	For Slum Redevelopment: Proportion of Rehab: Incentive FSI Island city- 1 : 0.75 Suburbs- 1 : 1 Difficult Areas- 1 : 1.33 Additional BUA for free sale ranging from 5% to 20 % will be admissible for plots 5acre to 40 acre	Island city = Total 2 1 Base FSI + 0.34 Premium + 0.33 TDR Suburbs = Total 2 1 Base FSI + 0.5 Premium + 0.5 TDR
Insitu FSI Consumption & TDR	For plots not under redevelopment - 2.5 FSI rehabilitation in situ 2.5 TDR as compensation to developer of Rehab DCR 33(10) applies for the plots where rehabilitation is happening using redevelopment	Insitu FSI may exceed 3 if existing DU on site between 500 DU/ha - 650 DU/ha Insitu may exceed 4 if existing DU/ha more than 650 Du/ha Rest floated as TDR	Insitu consumption for general plots: Island city = May exceed 1.8 Suburbs = May exceed 2.7 TDR floating permitted for some conditions	Not prescribed	May exceed 4	Island city = May exceed 2 Suburbs = May exceed 2 TDR floating permitted for some conditions

Density DU/Min	500 DU/Net Ha	500 DU/Net ha for regular slum redevelopment 650 DU/net ha for Dharavi Redevelopment Plan	For plots 1 ha and above Island City 267 Du/Net Ha/FSI Suburbs 200Du/Net Ha/FSI	Not prescribed	325 DU/Ha/FSI for rehabilitation/ Affordable housing Min 650 DU/ha could be reduced by chief fire officer by 25%	200 DU/Ha/FSI (1 ha and above)
Density DU/Max	No limit mentioned		600 DU/Net Ha/FSI Island City (1.33) 450 Du/Net Ha/FSI Suburbs (1)	For low income housing - 15sqm in size in 4 storied walkups, without possibility of incremental growth- 500 DU/ha is maximum density prescribed Otherwise 125 - 150 DU/gross ha for metropolitan housing	No limit mentioned	450 DU/Ha/FSI
Height	No limit (But until now the buildings have not been taller than 24m i.e. G+7 However there are plans to increase building heights for future)		The height of a building shall not exceed one and half times the total of the width of the street on which it abuts and the required front open space. Unless high rise permitted by Commissioner in accordance with min street widths mentioned in DCR	15 m for low income housing i.e G+4	No limit mentioned	The height of a building shall not exceed two times the total of the existing or prescribed width of the street on which it abuts and the required front open space. Unless high rise permitted by Commissioner in accordance with min street widths mentioned in DCR (min street width 9m for building 32 m in height.. onwards)

		(min street width 9m for building 32 m in height.. onwards)			
Setbacks and Step backs	<p>Front and side setback: 1.5m. for building up to 24m height 6m. for buildings above 24m. 3m where plot abuts DP road 18.3m wide No separate regulations for Stepbacks</p>	<p>Front: Varies from 7.5 to 3 m depending on street width Side and Rear: Width between internal buildings not less than a third of the height of that building above the ground level, rounded to the nearest decimeter subject to a maximum of 20 m. Minimum being 3.6 m. Differnt for detached buildings and row houses Step Backs allowed on upper floors for taller buildings This norm is separate and distinct for each building and wing</p>	<p>Front - 1.5 m to m depending on street width Side Open Space: For buildings above 10 m in height = Height/3 till the height of 30 m then +1 m for every 5 m height increase subject to a maximum of 20 m. Rear open space: Average width of 3.0 m and at no place measuring less than 1.8 m Step backs allowed on the upper floors for taller buildings This norm is separate and distinct for each building and wing</p>	<p>Front for building upto 32m is 3 min side and rear marginal open spaces may be reduced to 3.0 m. for a building with height more than 32 m but up to 70 m the side and rear marginal open spaces shall not be less than 6 m and for a building with height more than 70 m the side and rear marginal open spaces shall not be less than 9 m and 12 m beyond 120 m subject to fulfillment of fire safety requirement as specified in these Regulations.</p>	<p>Front varies from 6 - 3 depending on the Road Marginal and side open space for ht upto 32m is 3.6 m Beyond that: For plots under 1000 sqm is Height/5 subject to max 12 m For plots over 1000 sqm is Height/4 subject to max 12 m Different for semi detached row houses etc Step Backs allowed on upper floors for taller buildings</p>

Area between buildings	3 m min	Width between internal buildings not less than a third of the height of that building above the ground level, rounded to the nearest decimeter subject to a maximum of 20 m. This norm is separate and distinct for each building and wing	H/3 till the height of 30 m then +1 m for every 5 m subject to a maximum of 20 m. Sizes also provided for ventilation shafts for kitchens and toilets This norm is separate and distinct for each building and wing	Distance between two rehab buildings upto 32 m 6 m	Marginal and side open space for ht upto 32m is 3.6 m Beyond that: For plots under 1000 sqm is Height/5 subject to max 12 m For plots over 1000 sqm is Height/4 subject to max 12 m
Rehab Unit Size/ Unit Size	Used to be 20.9sqm changed to 25sqm in 2008 A multi purpose room shall be allowed with size upto 12.5 sqm with a minimum width of 2.4 m. Each house abuts common passages 2 m min Kitchen can be an alcove no size restrictions- no direct ventilation requirement/ mechanical is fine Bathroom no size restrictions - Artificial light ventilation is fine	No limit to unit size Min habitable room size 9.5 sqm - min width 2.4 m	Min habitable room size 9.5 sqm - min width 2.4 m Multipurpose single room should be at least 12.5 m ² with minimum width of 2.5 m	25 sqm A multi purpose room shall be allowed with size upto 12.5 sqm with a minimum width of 2.4 m. Each house abuts common passages 2 m min Kitchen can be an alcove no size restrictions- no direct ventilation requirement/ mechanical is fine Bathroom no size restrictions - Artificial light ventilation is fine	No limit to unit size Min habitable room size 9.5 sqm - min width 2.4 m

Windows size and design	<p>One or more apertures, excluding doors, with area not less than one-sixth of the floor area of the room, with no part of any habitable room being more than 7.5 m. away from the source of light and ventilation</p> <p>Habitable Room: At least a window not less than 1 sqm in area, opening directly on to an interior or exterior open space, but not into a shaft</p> <p>Kitchen Window: No Window / direct ventilation requirement - mechanical light an ventilation is fine</p> <p>Bathroom Window: No Window / direct ventilation requirement - mechanical light an ventilation is fine</p>	<p>One or more apertures, excluding doors, with area not less than one-sixth of the floor area of the room, with no part of any habitable room being more than 7.5 m. away from the source of light and ventilation</p> <p>At least a window not less than 1 sqm in area, opening directly on to an interior or exterior open space, but not into a shaft</p> <p>For towers external windows on a floor shall be not less than 2 1/2 per cent of the floor area</p> <p>Bathroom openings (windows, ventilators, louvers) not less than 0.3 sq. m in area or 0.3 m in width.</p>	<p>1/6th of the area of room should be window area for warm and humid - 25% higher window area for kitchen</p> <p>If a window is partly fixed, only the openable area shall be counted.</p> <p>No portion of a room shall be assumed to be lighted, if it is 7.5 m away from building</p>	<p>Habitable Room: Every Habitable room shall have window at least 1sqm in size</p> <p>For towers external windows on a floor shall be not less than 2 1/2 per cent of the floor area</p> <p>Bathroom openings (windows, ventilators, louvers) not less than 0.3 sq. m in area or 0.3 m in width.</p>
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Open Space Requirement	8% min on ground level	For plots over 1001 sqm depending on area of Plot 15% -25% of open space shall be reserved	Layout/plot measuring 0.3 ha or more for recreational purposes which shall as far as possible 15 percent of the area of the layout, or b) 0.3 to 0.4 ha/1 000 persons; for low income housing	8% min on ground level	For plots over 1001 sqm depending on area of Plot 15% -25% of open space shall be reserved
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Table 14. Comparison of three colonies under current study

DCRs	PMG Colony	Lallubhai Compound	Natwar Parekh
Year of approval as per building approval drawings	1997	2003 and 2007	2008
FSI	2.5	2.5	2.5 consumed 2.44
Net Study Area* (After removing Roads on municipal sheets and built up amenity area)	1.75	5.75	5.05**
Number of Units in Study Area (including shops)	1600	6318	5568
Density DU/ net ha in Net Study Area	914	1099	1103**
Area of window for multipurpose room	12-20% of room area (6.5 to 10% after accounting for shut pane of sliding window)	10% of room area (5% after accounting for shut pane of sliding window)	16% of room area (8% after accounting for shut pane of sliding window)
Window Design Features	Cross ventilated.	Not cross ventilated.	Not cross ventilated and opens to a common passage
Height	G+7 = 24 m	G+5 to G+7 = 18m to 24m	G+8 = 24 m
Distance between buildings	Mediated through courts measuring 10x10 m up to 16x16 m Each building has 4 light wells measuring 5x5m	3 m min distance	3 m min distance
Open Space Requirement	15%	15%	15%
Room Size	21 sqm	21 sqm	21sqm
<p>*NOTE 1:</p> <ul style="list-style-type: none"> *The Net Study Area is different from total plot area mentioned in the municipal drawings. Study areas are the areas of the colony where the TB study was mostly concentrated. Google Maps was used to approximate the study areas for the three colonies Number of units were derived from the Municipal Drawings – They include vacant units and shops. <p>** NOTE 2: The study area of Natwar Parekh compound is smaller in the Municipal Drawings than shown in the Google map. If that areas is used net density of Natwar Parekh Compound goes up significantly</p>			

<p>-Permissible built up area of each colony is calculated on the basis of the total plot area (Plot area X FSI)</p> <p>Study area is the area of the residential cluster where the BUA is constructed and study for TB was conducted</p>			
Plot Area as per drawings	15.14 ha	14.4 ha	16.13 ha
Net Study Area* after removing Roads and built up amenity area	2.7 ha	6.1 ha	5.16ha
Number of Units in Study Area (including shops)	1632 DU	Total built total units = 5184 Occupied total units = 4896 DU Residential at least: 4332 DU	Total built total units 5856 occupied total units 4800 aprox Residential at least: 5124 Du total occupied 4200 at least
Density DU/ ha in Study Area	635 units/net ha Residential at least:	Total Built for 850 units/Net ha Residential at least: 726 DU/ha	Total: Built for total 1313 units/net ha currently 1076 units/net ha Residential at least: built for 1149 DU/net ha Occupied 942 DU/net ha
Area of window	Type 1: $(1 \times 1.2 \text{ m}) \times 2 = 2.4$ + Bathroom ventilators 11.4% of room area Type 2: $(2.4 \times 1.2) + (0.6 \times 1.2) = 3.6$ + Bathroom Windows 17% of room area	$1.2 \times 1.5 = 1.8$ + Bathroom ventilators 8.5% of room area	$(1.2 \times 1.2) + (0.9 \times 1.2) = 2.52$ + Bathroom Ventilators 12% of room area
Study Area—Roads and built up amenity area	2.57 ha	6.1 ha	4.46 ha

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PMG COLONY



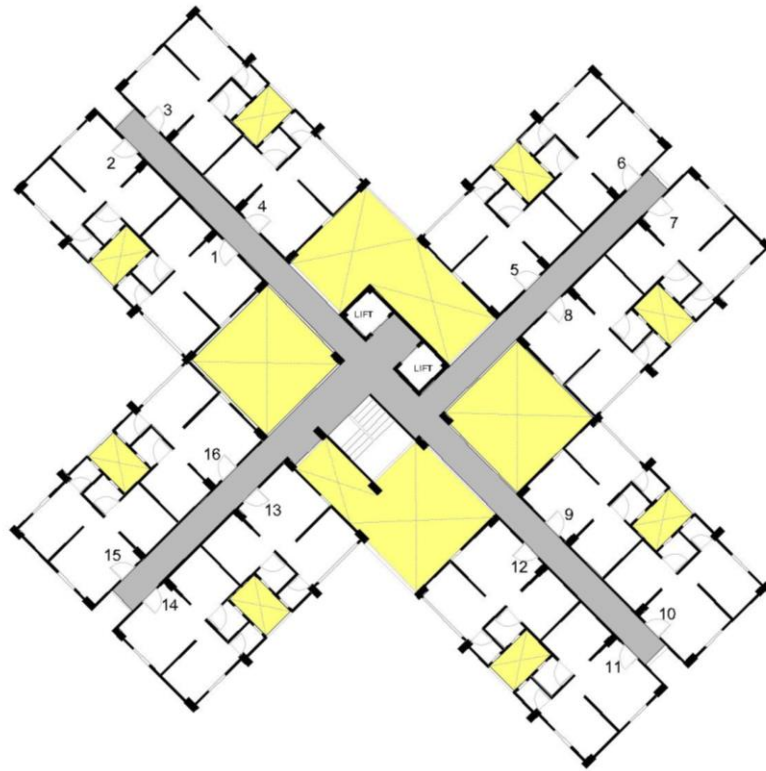
LALLUBHAI COMPOUND



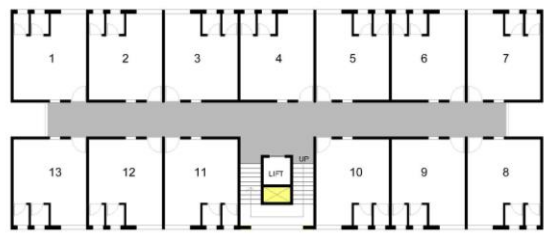
NATWAR PAREKH COMPOUND



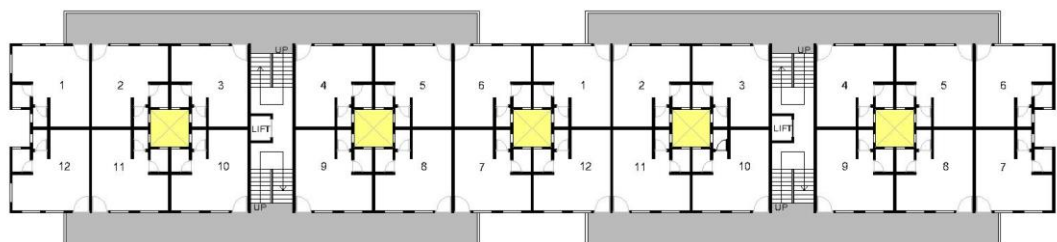
Fig. 48 Study area of the three resettlement colonies (a) and photographs of the open spaces between buildings in the three colonies.



PMG Colony Building Layout Plan



Lallubhai Compound Building Layout Plan



Natwar Parekh Compound Building Layout Plan

Analysis of DCR and Site conditions

FSI: In order to accommodate a higher number of formal dwelling units the in situ consumption of FSI on a plot has been increased since 1991 to 2015 years from 2.5 to 4. All three buildings studied are utilizing an FSI of 2.5.

Distance in between buildings: In order to accommodate for higher densities the distances between buildings has been relaxed from height/3m ~~for each building~~ to 3 m no matter the height of the building. This means that as per general building regulations the distance between buildings 24 m in height should be ~~8m~~ 16m. This is relaxed to 3m in the case of redevelopment buildings. This has affected the light and ventilation conditions in rehab colonies. Although some of the problems of light and ventilation can be improved using the step back norms for tall buildings, R & R and Slum rehabilitation buildings have not made use of these norms. Perhaps because the uniformity in units stacked over each other makes it difficult to make use of these norms structurally. The proposed DCRs (introduced in 2016) have recommended that the distance between buildings be increased from 3 m to 6 m for buildings up to 32 m in height. If adopted this norm will provide some relief to the congestion in the buildings. A stark difference in the quality of light and ventilation can be seen in PMG Colony vs Lallubhai and Natwar Parekh Compound. In PMG Colony, the distance in between buildings is mediated through courts measuring ~~15m x 15m~~ 10x10 m up to 16m x 16m. Each building also has internal light courts measuring 5x5 m. This provides for cross ventilation in the Colony and interiors of buildings.

Density: The NBC suggests a max dwelling unit (DU) density of 500 DU/ gross ha in the case of low-income housing that cannot be expanded. The DCRs allow for a min density of 500 Dwelling Units (DU)/net ha for redevelopment buildings. However the net density of DU/ha far exceeds this number. It is also important to note that the average number of people living in these households is larger (5.27 persons per unit) than the city (4.56 persons per unit). This leads to even higher population density and hence crowding in these areas.

The approximate DU/ net ha in the net study area of Natwar Parekh Compound is ~~1076~~ 1114units/net ha. Lallubhai Compound has a net density of ~~803~~ 1099units/net ha. As a result of larger distances between buildings, there is a lower ground coverage and hence lower density of homes per net hectare in PMG Colony. Density in study area of PMG Colony is ~~635~~ 914units/net ha. This is not below the minimum prescribed density of 500 DU/net ha in the DCR. Note that these are the net densities for which the colonies have been built. Some of these buildings in the Colony are lying vacant. The density calculation does not account for that vacancy.

Windows: The national building code prescribes that buildings in hot and humid area should have open window area as 1/6th the size of the room (17%). In Natwar Parekh Compound the windows are ~~12%~~ 16% of room area reduces to ~~6%~~ 8% after accounting for shut pane of sliding window. These windows also open to a common 2m wide corridor and many homes like to keep their windows closed or covered with curtains to maintain privacy. In Lallubhai Compound the windows are ~~8.5%~~ 10% of room area reduces to ~~4.25%~~ 5% after accounting for shut pane of sliding window. In PMG Colony the windows are ~~11.4%~~ 17% 12% to 20% of room area. This reduces to ~~5.7%~~ 8.5% 6.5% to 10% after accounting for shut pane of sliding window. Rooms in PMG Colony are also cross ventilated. TB cases in this Colony are negligible. Owing to better livability conditions, many residents from Lallubhai Compound and Natwar Parekh want to shift to PMG Colony.

Discretionary powers: Its important to note that although, as per Section 63 on Discretionary powers (Compilation Of Development Control Regulations up to 1st January 2015 for Mumbai, page 236), it is stated that:

“in specific cases where a clearly demonstrable hardship is caused, the Commissioner may for reasons to be recorded in writing, by special permission permit any of the dimensions prescribed by these Regulations to be modified”

The section only allows relaxations

“...provided that the relaxation will not affect the health, safety, fire safety, structural safety and public safety of the inhabitants of the building and the neighborhood”.

It could thus be seen that health and safety of occupants is of paramount importance. Therefore while devising separate set of regulations as well, health and safety of residents should not be compromised. So far, the rule has been used to provide concessions to the marginal and joint open space for all buildings. This should be stopped. In the light of the TB study findings, relaxations to the norms related to light and ventilations amount to a violation of the provisions in Section 63, as these relaxations are detrimental to the health of the inhabitants.

Recommendations

~~The existing built form and the relaxations in the DCRs that allow for its construction are detrimental to public health. We recommend a two-pronged approach to control the spread of TB in existing and future SRA and rehabilitation colonies.~~

~~**Retrofitting existing rehabilitation and SRA buildings** that are built after 1997. These are buildings that have been built at a distance of 3m from each other. In order to provide some relief to the people residing in the already existing resettlement colonies, some constructive interventions can be made. For example:~~

- ~~1. Change the sliding windows to openable windows~~
- ~~2. Install exhaust fans in the living area/kitchen area~~
- ~~3. Ventilators on the wall/door~~

~~One of the scenarios — an extra window in the living area of a tenement of Natwar Parekh compound — was modelled and simulation experiments were performed in order to see the possible impact of the intervention on the natural ventilation in the house (Fig 50 a-e). It was observed that by addition of this extra window, the air velocity in the living area increased considerably because of the cross ventilation. Since, none of the houses in this Colony have any windows for cross ventilation, this intervention may help in maintaining a healthier atmosphere in the house. Further it is essential that the sliding windows in these colonies are changed to fully openable as there is already a lack of ventilation between the buildings.~~

~~**Revert relaxations in standards for slum redevelopment:**~~

~~Our findings suggest that relaxation in building standards for slum rehabilitation and redevelopment are detrimental to the health of the poor who inhabit these homes and must be amended. It is imperative to revert the relaxations in standards on setback and dwelling unit density.~~

~~The general DCRs for Mumbai should be followed for adequate light, ventilation and density. Further modeling studies, similar to the ones carried out in this report, could be conducted to see the effect of light and ventilation in the rooms using the step-back methods of building and different building and open space layouts.~~

~~Window design can also be studied. We suggest that shutter windows instead of sliding windows are provided in rehabilitation homes to increase the size of openings~~

~~**Do not allow authorities to provide further concession:** Concessions that lead to overcrowding or compromise the light ventilation of homes in redevelopment/ rehabilitation homes must not be allowed~~

In the light of this study we would like to suggest two sets of recommendations:

B. Changes to DCRs :

Our findings suggest that relaxation in building standards for slum rehabilitation and redevelopment are detrimental to the health of the poor who inhabit these homes and must be amended. We suggest:

5. Exceptions made in DCR 33(10) – Appendix 4, Section 6.11 and 6.14 on marginal open space and area between two buildings, should be removed and general DCRs should be followed for the same.
6. Adoption of these regulations may not make it possible to attain the minimum requirement for densities. Hence it is recommended that regulations pertaining to minimum density in SRA buildings should also be removed.
7. For windows, we recommend that General DCR 42 be changed to read as:
“All parts of any room shall be adequately lighted and ventilated. For this purpose every room shall have - One or more apertures, excluding doors, with openable area not less

than one-sixth of the floor area of the room, with no part of any habitable room being more than 7.5 m. away from the source of light and ventilation.”

8. This DCR should be applied to DCR 33(10) without exceptions.
9. Do not allow authorities to provide concessions that compromise the light ventilation of homes , especially low income and slum rehabilitation homes.

B. Retrofitting of Existing Buildings:

To improve the light and ventilation conditions in SRA buildings already constructed under existing regulations, it is recommended that the following retrofitting measures be undertaken:

- All existing SRA buildings that have problems of ventilation should be retrofitted with appropriately placed exhaust fans.
- Three-leaf sliding windows or fully openable windows should replace the existing two-leaf sliding windows for better ventilation
- Ventilators on the wall/door: One of the scenarios – _an extra window in the living area of a tenement of Natwar Parekh compound- was modelled and simulation experiments were performed in order to see the possible impact of the intervention on the natural ventilation in the house (Fig 50 a-c). It was observed that by addition of this extra window, the air velocity in the living area increased considerably because of the cross ventilation. Since, none of the houses in this Colony have any windows for cross ventilation, this intervention may help in maintaining a healthier atmosphere in the house.

C. Study of Layout Design:

Well-designed layouts can make a difference to final conditions of light and ventilation. Further modeling studies, similar to the ones carried out in this report, could be conducted to see the effect of light and ventilation in the rooms using the step back methods of building and different building and open space layouts.